An age-Depth modeling method for improved treatment of uncertainty

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Age-depth modeling includes multiple sources of uncertainty. While most workers include uncertainty in measured age (e.g., calendar year ranges of calibrated radiocarbon dates), other sources, such as reservoir age and depth uncertainty, are less well understood and thus may not be fully considered. Uncertainty in the recovered position of material obtained by sediment coring and drilling is particularly common, often resulting from deformation of sediment during the recovery process or incomplete recovery. In some cases, adjustments can be made to partially compensate for movement of sediment layers in the core barrel, but the correction process also inherently includes some additional degree of uncertainty. To our knowledge, none of the commonly used age-depth modeling tools allows for inclusion of uncertainty in depth. Therefore we present a suite of age-depth modeling utilities with improved handling of uncertainty. Included are a function for reverse calibration of calendar year dates (e.g., tephras, U/Th, historical events) to radiocarbon age for calculation of reservoir age and its variability; a means for including uncertainty in recovered position of dated material and for specifying how that uncertainty is distributed (e.g., gaussian, uniform, etc.); the ability to increase overall uncertainty between widely spaced dates; detection of outlying dates; and merging of duplicate samples into multi-modal probability density functions. Modeling is performed from the bottom of the sequence upward in a frequentist framework. This suite of tools have been so far used to model ages in both open and restricted marine environments, lacustrine settings, and fossil coral sequences. The obtained linear sedimentation rates, or accretion rates in the case of corals, contain a more robust assessment of the uncertainty in the median modeled age at any given point. Final age probability is presented as a density cloud contoured between the 1st and 99th percentile ranges.

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